CLAIMS

What is claimed is:

1. A substrate comprising:

a base substrate;

an interfacial bonding layer disposed on the base substrate; and

a thin film adaptive crystalline layer disposed on the interfacial bonding layer, wherein:

the interfacial bonding layer is solid at approximately room temperature, and in liquid-like form when above room temperature;

the thin film adaptive crystalline layer has a degree of flexibility to expand or contract its lattice constant along a direction parallel to a surface of the substrate when the interfacial bonding layer is in liquid-like form; and

the base substrate is mechanically strong enough to support the interfacial bonding layer and the thin film adaptive crystalline layer thereon.

2. The substrate of claim 1, wherein the thin film adaptive crystalline layer comprises approximately the same crystalline lattice structure as $In_x(Al_yGa_{1-y})_{1-x}As$, wherein x is approximately 15% to approximately 45%.

3. The substrate of claim 1, wherein the substrate comprises a substrate for formation of a vertical cavity surface emitting laser based on $In_x(Al_yGa_{1-y})_{1-x}As$.

4. The substrate of claim 3, wherein x is approximately 15% to approximately 45%.

5. The substrate of claim 1, wherein above room temperature comprises a temperature of approximately 80°C to approximately 600°C.

6. The substrate of claim 1, wherein thin film adaptive crystalline layer comprises InGaAs with an In composition between approximately 15% and approximately 45%.

7. The substrate of claim 1, wherein the thin film adaptive crystalline layer comprises a compound semiconductor.

8. The substrate of claim 5, wherein the compound semiconductor comprises InP, GaAs, GaSb, or InAs.

9. The substrate of claim 1, wherein the base substrate comprises a semiconductor, an inorganic material, a metal, or a combination thereof.

10. The substrate of claim 9, wherein the semiconductor comprises GaAs, InP, GaP, Si or Ge, wherein the inorganic material comprises sapphire, poly-crystalline BN, or ceramics, and wherein the metal comprises Bi, In, Pb, Sn, Al, Ni, or metal alloy.

11. The substrate of claim 1, wherein the interfacial bonding layer comprises a single layer of the same material, or multiple layers of different materials.

12. The substrate of claim 10, wherein the single layer of the same material or the multiple layers of different materials comprise

Bi, In, Pb, Sn, Al, or Ni; or

a metal alloy; or

inorganic materials.

13. The substrate of claim 1, wherein the interfacial bonding layer comprises multiple thin metal films, wherein some of the films comprise liquid-like form at a temperature above room temperature, and some of the films remain solid at the temperature above room temperature.

14. The substrate of claim 13, wherein the temperature above room temperature comprises a temperature of approximately 80°C to approximately 600°C.

15. The substrate of claim 1, wherein the expansion or contraction of the lattice constant accommodates material epitaxial growth.

16. A substrate comprising:

a base substrate layer; and

an relaxed-strained thin film adaptive crystalline layer bonded to the base substrate layer and having a surface in-plane lattice constant different from that of the base substrate layer and close to that of a target material system.

17. The substrate of claim 16, wherein the in-plane lattice constant is in the same range as that of $In_x(Al_yGa_{1-y})_{1-x}As$, wherein x is approximately 15% to approximately 45%.

18. The substrate of claim 16, wherein the substrate comprises a substrate for formation of a vertical cavity surface emitting laser based on $In_x(Al_yGa_{1-y})_{1-x}As$.

19. The substrate of claim 18, wherein x is approximately 15% to approximately 45%.

20. The substrate of claim 16, wherein the thin film adaptive crystalline layer comprises InGaAs having an In composition between approximately 15% and approximately 45%.

21. The substrate of claim 16, wherein the base substrate comprises GaAs, and the thin film adaptive crystalline layer comprises $In_x(Al_yGa_{1-y})_{1-x}As$.

22. The substrate of claim 21, wherein x is approximately 15% to approximately 45%.

23. The substrate of claim 16, wherein the thin film adaptive crystalline layer comprises a semiconductor.

24. The substrate of claim 23, wherein the semiconductor comprises InGaAsP, GaSb, InGaAs, InGaP, AlGaP, InSb, InP, AlSb, or InAs.

25. The substrate of claim 16, wherein the base substrate layer comprises semiconductor, an inorganic material, a metal, or a combination thereof.

26. The substrate of claim 25, wherein the semiconductor comprises GaAs, InP, GaP, Si, or Ge.

27. The substrate of claim 25, wherein the inorganic material comprises sapphire, poly-crystalline boron nitride, or ceramics.

28. The substrate of claim 25, wherein the relaxed-strained thin film adaptive crystalline layer is fabricated having a strained lattice constant equal to a lattice constant of a first semiconductor substrate on which it is grown, which strained lattice constant has been adjusted by bonding the thin film adaptive layer to a carrier substrate via an interfacial bonding layer and removing the first substrate, and then heating the interfacial bonding layer to liquidize the interfacial bonding layer to allow the strained thin film adaptive layer to relax to its unstrained lattice structure to form the relaxed-strained thin film adaptive layer, and then bonding the thin film layer to the base substrate and removing the carrier substrate to expose an epitaxial growth surface of the thin film adaptive layer.

29. A method of forming a substrate for formation of semiconductor devices, comprising:

forming a thin film layer having a first lattice constant on a first substrate;

bonding a first surface of the thin film layer to a surface of a second substrate, via an interfacial bonding layer that is solid at approximately room temperature and in liquid-like form when above room temperature; and

removing the first substrate to expose a second surface of the thin film layer, wherein a target material system having a second lattice constant different from the first lattice constant may be epitaxially grown on said second surface of the thin film layer by heating the interfacial

bonding layer during said epitaxial growth to the liquid-like form to provide the thin film layer with lattice flexibility to permit the lattice constant of the thin film layer to adjust to that of the target material system during said epitaxial growth.

30. The method of claim 29, further comprising, before forming the thin film layer, forming an etch stop layer on the first substrate.

31. The method of claim 29, further comprising treating the surface of the second substrate prior to the bonding.

32. A method of forming a substrate for formation of semiconductor devices, comprising:

forming a strained pseudomorphic thin film adaptive layer on a first substrate;

bonding a first surface of the thin film adaptive layer to a carrier substrate with an interfacial bonding layer;

removing the first substrate by selective etching or lift off and leaving the thin film adaptive layer;

liquidizing the interfacial bonding layer to allow the strained pseudomorphic thin film adaptive layer to relax its unstrained lattice structure;

bonding the surface of the thin film adaptive layer to a second substrate; and

removing the carrier substrate to expose a second surface of the thin film adaptive layer.

33. The method of claim 32, further comprising treating the surface of the second substrate prior to the bonding.

34. The method of claim 32, wherein the liquidizing comprises heating the interfacial bonding layer.

35. An optoelectronic apparatus, comprising:

(a) a substrate comprising:

(1) a base substrate;

(2) an interfacial bonding layer disposed on the base substrate; and

(3) a thin film adaptive crystalline layer disposed on the interfacial bonding layer, wherein:

the interfacial bonding layer is solid at approximately room temperature, and in liquid-like form when above room temperature;

the thin film adaptive crystalline layer has a degree of flexibility to expand or contract its lattice constant along a direction parallel to a surface of the substrate when the interfacial bonding layer is in liquid-like form; and

the base substrate is mechanically strong enough to support the interfacial bonding layer and the thin film adaptive crystalline layer thereon; and

(b) an optoelectronic device epitaxially grown on the thin film adaptive crystalline layer.

36. The optoelectronic apparatus of claim 35, wherein the optoelectronic device is a semiconductor laser.

37. An optoelectronic apparatus, comprising:

a substrate comprising:

a thin film adaptive crystalline layer; and

a base substrate layer, the thin film adaptive crystalline layer bonded to the base substrate layer and having a surface in-plane lattice constant, and wherein the in-plane lattice constant is different from that of the base substrate layer, wherein the thin film adaptive crystalline layer comprises a strained pseudomorphic thin film grown on a first semiconductor substrate that is bonded to and transferred to a second carrier substrate, wherein the first semiconductor substrate is removed and the in-plane lattice constant relaxes from an original strained value to a new value close to an unstrained lattice constant, and wherein the thin film adaptive crystalline layer is physically or chemically bonded to the base substrate layer with or without an interfacial bonding layer; and

an optoelectronic device epitaxially grown on the thin film adaptive crystalline layer.

38. The optoelectronic apparatus of claim 37, wherein the optoelectronic device is a semiconductor laser.